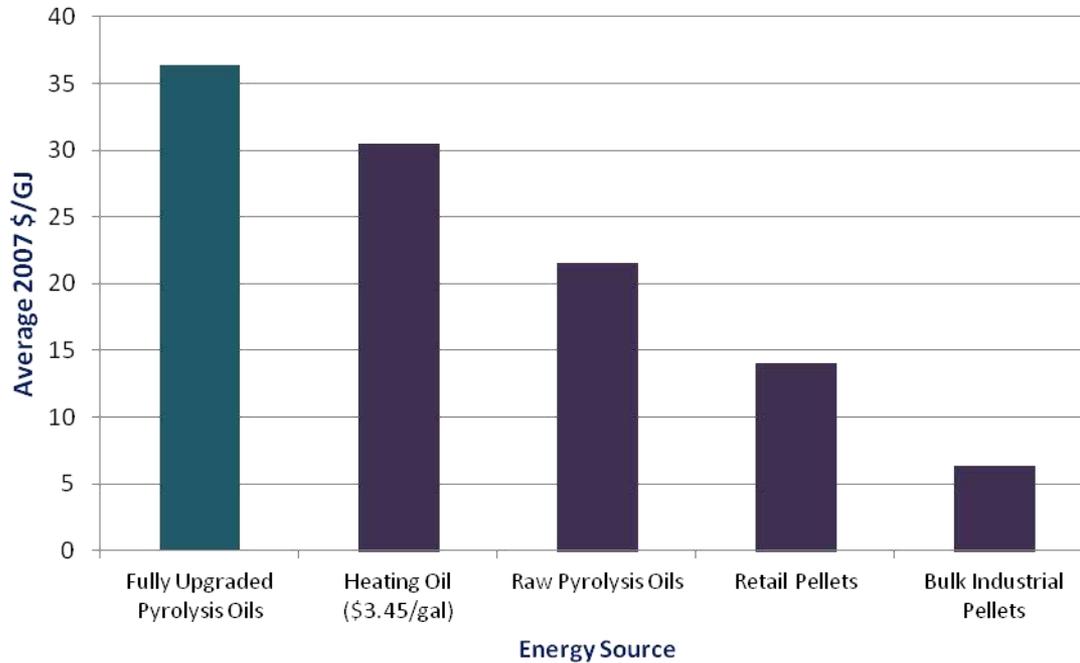


Biomass Derivatives Competitive with Heating Oil Costs



- Transportation fuel
- Heat or electricity

- Data are from literature, except heating oil is adjusted from 2011 winter average
- Fuel costs vary widely based on feedstock, location, and technology option
- Retail pellet costs are based on current prices in NE (~\$243/ton)

- **Densifying biomass for heating (e.g. pyrolysis oil or pellets) can be a cost-competitive feedstock for residential heating system**
- **These are not “drop-in” fuels for current liquid handling/infrastructure/applications**
- **Logistics and supply chain considerations begin to predominate for residential biothermal**

Biothermal Offers Competitive Economics Particularly in Northeast

Bio-oils as a heating oil substitute may present a significant opportunity to solve a relevant problem, save consumers money... particularly in the Northeast

Biothermal leverages ongoing work in the OBP bio-oil production and upgrading and other work in thermochemical including:

- Corrosion/material compatibility
- Feedstock logistics and pre-processing
- Densification
- Fast pyrolysis

Heating Oil Prices and Pyrolysis Oil Price Projections in 2011



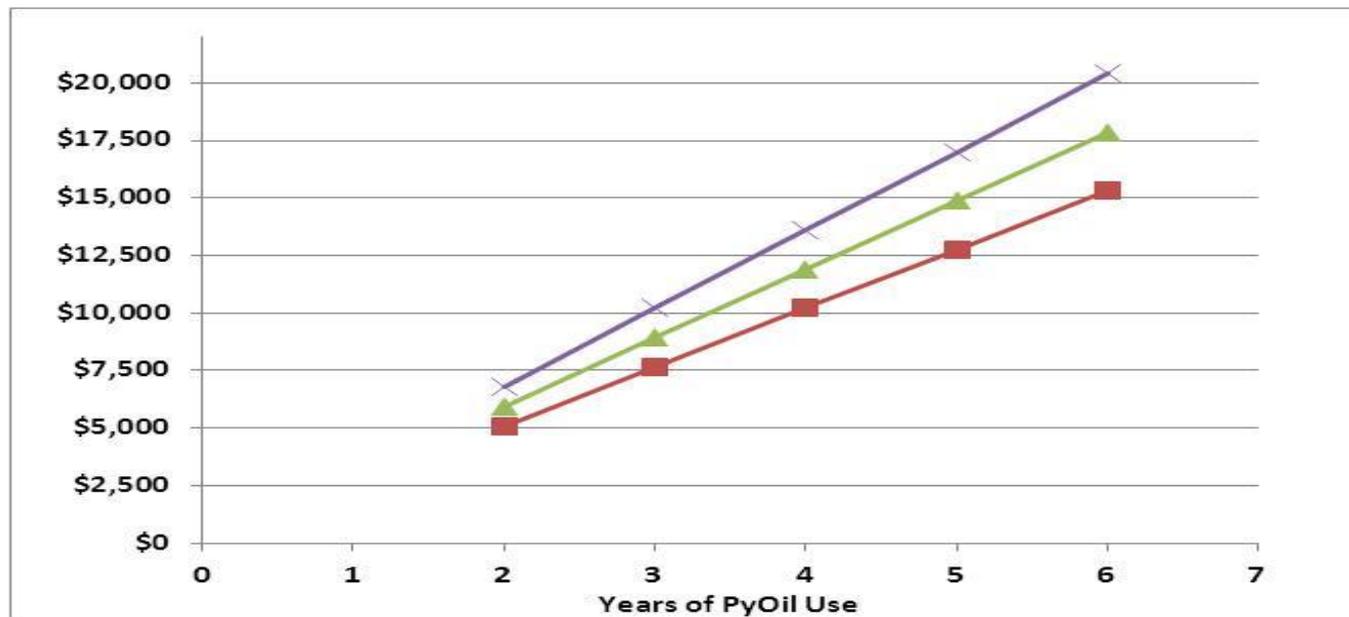
Oil Type and Price

- What will it take to make pyrolysis oil an acceptable substitute for heating oil?
- How much conditioning and supply chain changes will it take to make the pyrolysis oil acceptable?
 - Final fuel specifications for home and institutional heating – should we target different specifications for each market?
 - Is pyrolysis blending with heating oil a worthwhile possibility?
 - Can we get the costs of fully conditioned pyrolysis oil below that of heating oil?
 - What R&D and certifications are required?
 - What are the critical gaps in our analysis and understanding?
 - What might be an achievable time frame and at what cost will make this happen (wild guess)?
- What else should we be asking?

Benefits of Pyrolysis Oil Substitution for Heating Oil

Substitute Pyrolysis Oils for Heating Oil

- Burner injectors and nozzle replacements likely required
- New injectors and nozzles assumed to be \$1,000 per furnace
 - Full tank replacement assumed to be \$1,800 - \$5,000

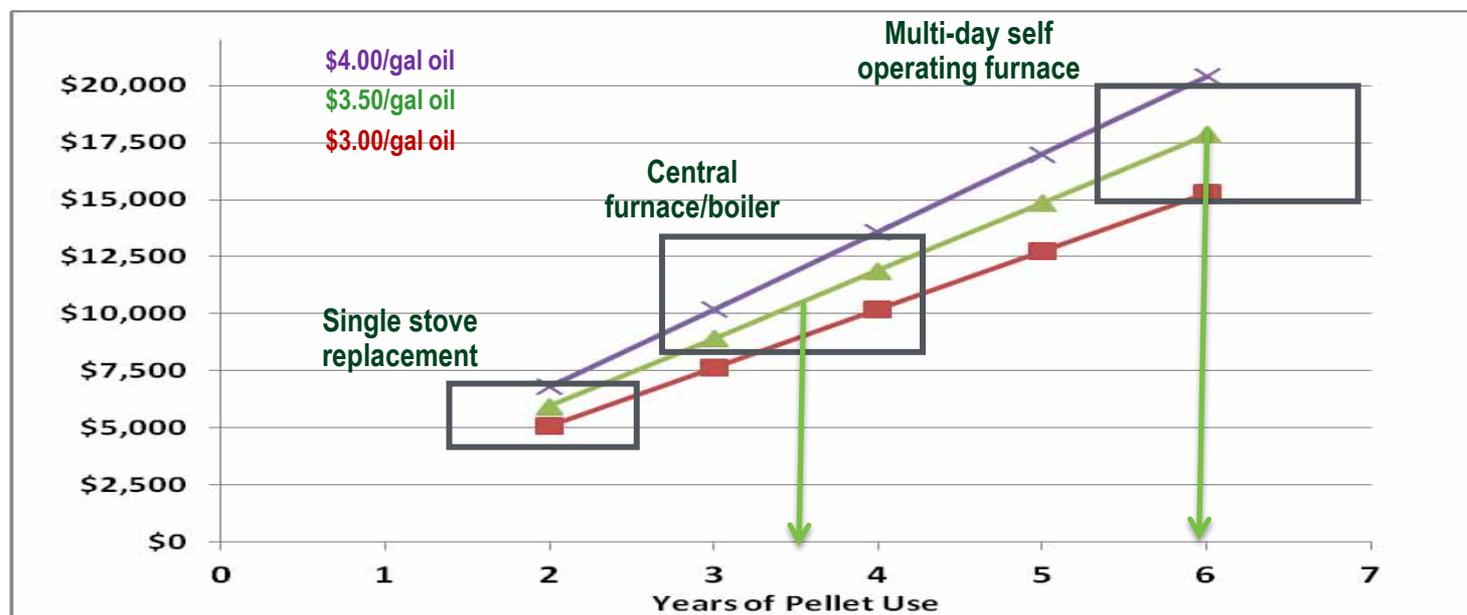


- ❖ Payback occurs within 4 years for most households
- ❖ Retrofit payback likely to occur within 0.5 – 3 years, depending on tank swap out requirements

Benefits of Substitution of Pellets for Heating Oil

Replace Fuel Oil Furnace with Pellet Stove(s)

- Average cost of one pellet stove installation is \$3,000-4,000
 - Central furnace replacement cost is \$8,000-10,000
 - With self-feed hopper, costs can amount to >\$15,000



- ❖ Payback occurs within 4-6 years for most households
- ❖ Payback period would be reduced with lower price of pellets, or higher priced oil
- ❖ We have not yet addressed GHG benefits

- Northeast is largest regional consumer of heating oil in the U.S.
- Northeast is the location of >80% of the 7.2 million U.S. homes that used heating oil in 2009
- Average household consumes 850 gallons of heating oil per season (October – March)
- New York, Maine, Massachusetts, New Jersey, and Vermont have announced state mandates to transition to ultra-low sulfur fuels

Northeast Heating Oil Supply-Demand Balance and Projections: Annual Average 2007-2013

(Thousand bbl/d)

(Rounded to closest 10,000 bbl/d)

	2007	2008	2009	2010	2011*	2012 Outlook	2013 Outlook
Consumption	470	370	360	310	290	310	280
Supply	470	370	360	310	290	340	310
In-Region Production (+)	210	190	160	140	140	120	100
Net Receipts from Other Regions (+)	180	170	170	140	160	160	160
Imports (+)	80	70	100	80	60	60	50
Exports (-)	40	60	50	50	80	–	–
Stock Decrease (+) / Increase (-)	40	–	-20	–	10	–	–
Surplus (+) / Gap (-)	–	–	–	–	–	30	30

*Data through November 2011.

Notes: Projected consumption is based on data from EIA's *Short-Term Energy Outlook*. It includes a switch in consumption from heating oil to ULSD of an additional 70,000 bbl/d beginning in July 2012, based on New York's requirement that heating oil move to ULSD specifications. Projected production is based on assumed yields and the capacity of remaining refineries. Sunoco Philadelphia is assumed to close in July 2012. Projected imports are 3-year historical averages adjusted down by U.S. Virgin Islands contributions. Historical net receipts are estimated. Projected net receipts are 3-year historical averages. The Surplus/Gap indicates the under- or over-supply needed to meet consumption.

Source: U.S. Energy Information Administration.

Biomass is Competitive with Heating Oil Costs

- Data are from literature, except heating oil is adjusted from 2011 winter average
- Fuel costs vary widely based on feedstock, location, and technology option
- Conditioned pyrolysis can be substituted for heating oil in NE
- Retail pellet costs are based on current prices in NE

